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NOTES FROM THE PHYSICAL LABORATORY.

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The Effect of Temperature, Pressure and Used Solutions on the Deposit of Silver Voltameters. By J. F. MERRILL.

The object of this investigation was to see if by means of temperature or pressure the amount of the electric charge carried by silver ions in the electrolysis of silver nitrate could be varied. It is well known that the amount of the silver deposit, as obtained in ordinary electrolysis, varies slightly according to the conditions under which the deposit is obtained. But that this variation is due to any change in the carrying capacity of the silver ions has probably not been proved.

Preliminary experiments having shown that the pressure had to be considerable if any measurable effect was to be obtained, a piece of apparatus was made by means of which the voltameter could be subjected to a gaseous pressure of 120 atmospheres. The pressure cage was made by boring a hole 3¼″ diameter in a piece of steel shafting, threading it, and then screwing it down upon a suitably prepared base, up through the bottom of which the conducting wires passed and the gas was admitted. The Rayleigh form of silver voltameter was employed. The Pt. dish was 7 cm., and the silver anode 4 cm. diameter respectively. Two voltameters alike in all respects were provided, and the deposit under atmospheric conditions compared with that obtained under pressure. The pressure was secured by admitting compressed air from a cylinder into the cage.

The following results were obtained:—

No. Experiment.	1	2	3
Pressure in Atmospheres...	103	95	103
Deposit in air..................	1.1371	1.23745	1.08205
Deposit under pressure......	1.1370	1.23740	1.08190
Diff. in Deposit...............	0.0001	0.00005	0.00015

The time of deposit was about 32 minutes. According to these results, no effect outside of the limits of experimental error was produced.

The effect of air absorbed under pressure was tested, two deposits being made after the voltameter had stood during several hours under a pressure of 90–100 atmospheres. The difference in the deposits as obtained in air and under pressure were 0.00000 and 0.00010 gr. respectively. This result may be reconciled with what Schuster and Crossley (Proc. Roy. Soc., 40, p. 344, 1892) and Meyers (Wied. Ann., 55, p. 288, 1895) found, that dissolved gases affect the amount of the deposit, if it is remembered that oxygen and CO_2 decrease and nitrogen increases the deposit.

To test for a temperature effect it was found necessary to replace the Pt. dish by a Pt. disc suspended horizontally near the top of the electrolyte just as the anode ordinarily is. In this case the anode was at the bottom of the beaker. Here again the two voltameters were alike and were placed in series. The solution in one was boiled and then cooled to the temperature of melting ice and the deposit from this compared with that obtained from a solution maintained at about 90° C. In these experiments the amount of each deposit was about 0.8 gr., the current intensity 0.25–.3 amp., and the kathode discs about 13 sq. cm. in area. The average difference in the deposits was about 1 part in 8000—within experimental error.

This result is apparently not in agreement with four observations made by Rayleigh, who found a difference of about 1 part in 2500 in favor of a solution at 50° C. as compared with one at 4° C.; but it is in agreement with two observations made by Kahle (Zeitschr. für Instr., 8, p. 229, 1898). But if the deposit from the hot solution or from a solution previously boiled and then cooled was compared with that obtained from an unboiled solution, the former seemed to be greater than the latter in amounts varying from 0.00–0.08 per cent.

However, using the Rayleigh form of voltameter the deposit from a boiled and then cooled solution did not differ more than 0.2 mg. from that of a solution not boiled. Though the deposits from cold and hot solutions respectively did not differ in amount, they did differ in character. Those from cold solutions were always fine grained and snowy white in color, while those from hot solutions were more coarsely granular with a tendency toward gray in color.

Next, the deposit from a previously boiled and then cooled water solution was compared with that obtained from fused silver nitrate. The results of the last seven experiments are here given:—

Temp. of fused Ag. NO_3..	260°	255°	250°	245°	243°	242°	243°
Solution deposit............	0.7224	0.7307	0.90250	0.79955	0.8511	0.88965	0.9068
Fusion deposit..............	0.7230	0.73075	0.90285	0.79955	0.85115	0 89080	0.90665
Diff........................	0.0006	0.00005	0.00035	0.00000	0.00005	0.00125	0.00015

Though these results show a difference in favor of the deposit from the fusion, yet this is probably accidental and due to some particles of foreign matter that could not be washed off; for there was always more or less of a scum floating on the surface of the fused silver nitrate, some of which adhered to the kathode when removed.

Two different series of tests were made on the relative deposits from fresh and "used" solutions, the voltameters (Rayleigh form) being alike in all respects. The first "used" solution tested was made on November 27, its volume was 300 cc., contained 15 per cent. silver nitrate, and from it 52 gr. of silver had been deposited when this series began, January 16. Five tests were made and 69 gr. of silver had been deposited from the used solution when the last test began. The result of the five closely agreeing measurements gave an increase in deposit from the old solution of 1 part in 11600.

More than two months later another series of tests on this point was made, the old solution by this time having been used a great many times, portions from it repeatedly boiled, and about 55 grams more of silver deposited from it.

The deposit from this solution was compared with that from two different 15 per cent. fresh solutions, and was greater in amount by about 1 part in 1700. Moreover, this was a percentage increase, as was proved by currents of different intensities and deposits of different amounts. But in every case in both these series of tests, the deposit from the fresh solution was more coarsely crystalline (varying from slightly to decidedly), and slightly less white in color than that from the old solution—just the opposite of what Kahle found. Furthermore, a test with litmus paper and with a litmus solution failed to show any acidity in either the fresh or "used" solutions. This again is not in agreement with Kahle's observations. But after each experiment the anodes were always more or less coated with grayish black matter, which Kahle says is coexistent with the formation of free acid in the electrolyte.

It is not impossible that the discrepancies between the results of Kahle and my own are due to the different shapes of anodes used in the two investigations. I hope to study this possibility very soon.

The silver nitrate and anodes were all obtained as c. p. from Eimer and Amend, New York.

Note on the Energy Spectrum of a Black Body. By F. A. Saunders.

In the *University Circulars* for June, 1897, and June, 1898, preliminary accounts were given of the work in progress at the time by Dr. C. E. Mendenhall and the writer on the above subject. The same work has been continued this year by the writer alone, the present object being to map out the distribution of energy in the spectrum of an absolutely black body at temperatures below 500° Centigrade, and to carry the measurements down to temperatures as near that of the room as possible. The black body was one of the same form as before, being an enclosure with walls at a uniform temperature, with a small slit cut in the walls to allow some of the radiation within to pass out to the measuring apparatus. The latter, as before, consisted of a moveable-arm spectrometer of the same form as that first used by Langley, equipped with a rock salt prism and lens, and a bolometer whose exposed strip covered an angle of five minutes in the spectrum. The galvanometer used was also the same, one of the four-coil pattern with a resistance of 4 ohms, with all the coils connected in parallel. The distance between the coil centres was 1 inch and the waste space at the centres 3 mm. in diameter.

As the amount of radiation to be measured was very small, and as there are several lines of electric cars near the laboratory which produce disturbances in any ordinary galvanometer system, a great deal of time was spent in the attempt to make a system which would be to a high degree both sensitive and astatic. The magnets used for this purpose were made from watch hair spring, the best size being 0.05 mm. thick and 0.24 mm. wide, tempered and broken off into various lengths, from 0.5 mm. to 2.5 mm. These were mounted by means of shellac, or shoemaker's wax, on a very fine glass tube, and a fragment of silvered microscope cover glass of an area of about 1.5 sq. m was attached as a mirror The weight of the entire system was from 2.5 to 3 mg. Fourteen different forms were constructed, in which the weight was kept nearly the same, but the number, length and arrangement of the magnets was varied. It was found as a result of these experiments that there was a limit with this particular galvanometer at least, both to the shortness and the thinness of the magnets, beyond which it was not profitable to go. The form finally chosen as the best was one in which each magnet set consisted of three, of lengths 1.6 mm., 2.3 mm. and 1.6 mm., the weight of the entire system being between 2.4 and 2.5 mg., and of the magnets alone 1.3 mg. With this form a current of $7.7.10^{-11}$ amperes produced a deflection of 1 mm. on a scale at a metre's distance, when the system had a complete period of 10 seconds.

Great difficulty was experienced in obtaining any system which would retain a long period for more than a day, whether the magnets had been boiled or not, but by making a great number of systems, and carefully adjusting their magnetic condition from day to day, one was finally obtained which held a complete period of five seconds for two weeks without alteration, and it was not possible to obtain anything better than this. The galvanometer was shielded by four cylinders of wrought iron, from $\frac{1}{4}$ to $\frac{3}{8}$ inch in thickness, and with these precautions the system was quite steady even at high sensibilities.

The black body was a double-walled vessel of sheet copper, the inter-space of which could be filled with liquids whose boiling points gave the desired temperatures. Its dimensions were: outside diameter 13.7 cms., outside height 17.5 cms., inside diameter 7.5 cms., and inside height 11.2 cms. The slit was 3 cms. by 0.6 cms., its area being about $\frac{1}{90}$ of the total internal area of the black body. In order to reach the higher temperatures obtained, the vessel was enclosed in an asbestos furnace, and its bottom was shielded by fire-clay from direct contact with the flames. By arranging these so that they nearly enclosed the entire vessel, and leaving the inter-space empty, a fairly uniform temperature was obtained in the interior.

Energy curves were taken at the following temperatures:—578°, 503°, 399°, 313°, 243°, 175° and 100° Centigrade, and from their form, though the final corrections have not yet been applied to them, it is evident that they furnish, at least approximately, a confirmation of the formula for the distribution of energy deduced theoretically by Wien and experimentally by Paschen. The drawing of the true curves is, however, as before, made very uncertain by a great number of absorption bands, which were always present, although special precautions were taken to have the air about the spectrometer as dry and as free from carbon dioxide as possible.

It was intended to obtain a curve also for the temperature of −183° Centigrade, given by the boiling of liquid air, but unexpected difficulties were encountered in obtaining any of this fluid, and it was not possible to carry out this extension. A small amount was, however, procured through the kindness of Prof. William Simon of the Maryland College of Pharmacy, but it evaporated completely as soon as it was placed in the black body and failed to reduce its temperature lower than −90° C. At this point a small deflection was obtained, of about the amount expected from the formula, at at a wave-length of $10\,\mu$, which is where the maximum energy at this temperature should fall if the product of the absolute temperature and the wave-length of the maximum of the energy-curve is a constant quantity—as follows from Paschen's formula. It is interesting to note that if the formula holds down to −183° C., the maximum of the curve will be found at about $30\,\mu$, and will therefore be beyond the reach of any rock-salt dispersion apparatus.

On the Absorption of Ice in the Ultra-red. By F. A. Saunders.

The object of this experiment was to determine the absorption of ice and to compare it closely with that of water, using the same amounts of both, in the attempt to find whether the change in physical state produced any change in the absorption.

The spectro-bolometer used is described in the previous note; but the source of radiation was a blackened platinum strip electrically heated. This was placed 8 centimetres from the optical slit of the spectrometer, and at a distance of 2 centimetres there was an arrangement by which a cell containing water could be interposed in the path of the radiation. This cell consisted of a small frame cut out of sheet brass, surrounding a hole 1.2 × 3 centimetres, over which thin pieces of mica were fastened on both sides, enclosing between them a space as thick as the brass frame itself. This was set in a slide so that it could be dropped to the bottom of a narrow empty tin tube, 20 cms. in length, which could be completely surrounded by a freezing mixture when desired. Two cells were used, of 0.8 and 0.25 mm. thickness.

The absorption of the mica sides alone was first measured; then that of the cell filled with water, and finally this was dropped into the cold air in the tin tube and frozen. It was then interposed in the path of the radiation only for the instant required to measure its absorption, and at once dropped back into the cold air. It was only with this arrangement that it could be kept frozen as long as was necessary.

The results indicate that there is no difference in the absorptions of water and ice between the limits investigated. In the case of the cell 0.8 mm. thick, the absorption of the water (or ice) was 4.5 per cent. of the incident energy at the limit towards the short wave-lengths, about 0.97 μ, increased very rapidly between 1.2 μ and 2 μ, and became practically complete at 3.2 μ. In the case of the thinner cell it was 4 per cent. at the short wave-length end, increased most rapidly between 2 μ and 3 μ and became complete at 5 μ. The mica sides alone transmitted from 65 per cent. to 85 per cent. of the incident energy, and were thus quite satisfactory.

Notes on the Zeeman Effect. By H. M. Reese.

The work has been confined to a comparatively exhaustive study of the iron spectrum between wave-lengths 3400 and 4500, and of the spectra of magnesium, cadmium, and zinc. The spectra were obtained by a concave grating of 15000 lines per inch, 21 feet radius. Photographs were taken of the effect as seen when viewed across the field of force, and also in the case of iron, as seen along the field. The time of exposure varied from fifteen minutes to one hour and a half, according to the region in the spectrum and the brightness of the lines.

In the case of iron, the intensity of the field used is unknown for the reason that the introduction of an iron terminal to get the spark seriously disturbs the field; and it is impracticable to make the measurement with the terminal in position. With the exception of the cases of reversed polarization discovered last year, all the iron lines examined appeared as plane triplets of the usual type when viewed across the field, or as quadruplets, or else were apparently unaffected. There are four quadruplets, viz., the lines 3466.0, 3475.6, 3490.7, and 3587.13. In the case of 3466.0 and 3475.6, a Nicol's prism was used, which showed that in each case the inside pair of components was due to vibrations along the field, the outer pair to vibrations across the field. In physical character the four lines differ somewhat. In 3466.0 the middle pair of components are five or six times as intense as the outer pair and are not very sharp, while the space between the inner pair is considerably greater than that between either member of this pair and the outside component adjacent to it. The other three quadruplets are more uniform in intensity; and their components are more uniformly spaced; further, all are quite sharp though rather faint. All four are, so far as I can judge, symmetrical as regards intensity, and probably also as regards spacing; but the most careful measurements that I could make indicated a possibility that in the case of 3466.0 the mean of the inner pair is a trifle farther toward the red than that of the outer pair. The separation of the outer pair in the several cases is .76 Ångström units for 3466.0, .50 for 3475.6, .48 for 3490.7, and .40 for 3587.13. In this same region the triplet 3476.9 is worthy of mention here because of the very wide separation, .72 Ångström units, between its lateral components; the same measurement in other triplets of the region varying from .39 down to a mere broadening. It is rather remarkable that so many lines of an unusual character should occur so close together. This region also shows several triplets in which one lateral component is apparently more intense than the other, but in every such case the whole triplet is so very faint that I took little notice of the phenomenon until my attention was called to it by Dr. Zeeman's paper in the January number of the *Astrophysical Journal*, in which he showed that such cases were due to superpositions of other lines.

In the experiments with magnesium, cadmium, and zinc, the field used was in most cases about 25000 C. G. S. units, and I think fairly uniform, for the faces of the pole-pieces were nearly flat and so close together that they left only a space about one-eighth of an inch wide for the spark.

The most interesting line in the spectrum of magnesium is 3832.45, one of a group of three very strong lines belonging to the first subordinate series. This line has at least five components, viz., a very strong central one (which may be further resolved in a stronger field), and two lines symmetrically situated on either side of it. Of these latter, the two extremes, which are very faint, are like the central component due to vibrations normal to the field, while the other pair are due to vibrations along the field. The separation of the faint extremes is .60 units, that of the inner pair .23 units. The other two lines of the group, 3829.5 and 3838.4, are triplets, the former sharp, the latter rather diffuse.

In the *Philosophical Magazine* for February, Dr. T. Preston gives a relationship between the separation for certain corresponding lines of magnesium, cadmium, and zinc. He finds that the value of $\frac{\lambda^2}{\Delta\lambda}$ is 18 for the lines Mg 5183.8, Cd 5086.0, Zn 4810.7; 11.5 for Mg 5172.8, Cd 4800.1, and Zn 4722.3; and 10 for Mg 5167.5, Cd 4678.4, and Zn 4680.4. Moreover, the first three lines are diffuse triplets, the second three are quadruplets, and the third three are sharp triplets. My plates show very fair agreement with Dr. Preston's results. My values of $\frac{\lambda^2}{\Delta\lambda}$ are .39 for Mg 5183.8, .34 for Cd 5086.0, .35 for Zn 4810.7; .21 for Mg 5172.8, .22 for Cd 4800.1 and Zn 4722.3, and about .19 for Mg 5167.5, Cd 4678.4 and Zn 4680.4; or approximately .36, .22, and .19 for Preston's three groups, which are nearly proportional to his figures. Only proportional agreement is to be expected, since the field used was different in the two cases. His statements in regard to the physical character of the lines are also confirmed by my plates.

In the report of last spring in this *Circular* and in the *Astrophysical Journal*, it was shown that the iron lines could be arranged in groups with regard to the magnitude of the separation which coincided with those found by Humphreys with regard to the shift due to pressure, at least so far as the spectrum had been examined. This, however, is certainly not the case with magnesium, cadmium, and zinc. For instance, the pressure-shift was found to be approximately the same for the three *b*-lines of magnesium, but the magnetic separation is about twice as great for 5167.5 as for 5183.8. Again, the cadmium lines 3403.7, 3467.7 and 3613.0 exhibited the same pressure-shift, but on my plates 3403.7 appears to be unaffected by the field, while the other two lines, although not sharp enough to be measured, are considerably broadened, if not separated. Other examples may be given to the same effect.

In the paper already cited, Dr. Preston states that he was unable to observe the cases of so called "reversed polarization" observed by Becquerel and Deslandres in France, and afterward in this laboratory. Now, while it may very well be that what we observed as a single central line would prove to be a pair in a stronger field, showing the supposed triplet to be a quadruplet of a possible type discussed in Dr. Preston's paper, I am inclined to put more faith in our own results than in his, because he states that he had to make an exposure of four hours to get these lines, and of course could not maintain a strong field for that length of time. Not only does a long exposure necessitate a weaker current to excite the electro-magnet, but it entails great liability of bad definition in the photograph on account of slight jars about the spectrometer.

It is probable that no entirely satisfactory results from the Zeeman effect can be secured until a very uniform field of great strength is obtained. Many of the deviations from the common triplet may be due to sensible differences in the strength of the field at different parts of the source of light.

Electric Absorption in Condensers. By L. M. Potts.

In the *University Circular* for June, 1898, there was a note on Electric Absorption in Condensers by H. A. Rowland and T. D. Penniman. In the present investigation, a direct method of measuring the resistance due to the electric absorption has been used.

Professor Rowland, by extending Maxwell's equations of a stratified dielectric to the case of such a dielectric acted upon by a periodic electromotive force, has found that if i is the current intensity, the e. m. f., E may be reduced to the form

$$E = i\left(R + \frac{1}{ibc}\right)$$

so that the condenser with absorption acts as a condenser of capacity c, without absorption, in series with an ohmic resistance R.

The arrangement used for the determination of the value of the electric absorption, was a Wheatstone bridge. The condenser, whose absorption was to be measured, and the fixed coils were placed in series in the arm 1 of bridge. The hanging coil was put in circuit with the cross connection of the bridge. The phases of the currents in the fixed and hanging coils of the dynamometer will differ. If this difference is 90° there will be no deflection.

Let $R_1 \equiv$ resistance of arm containing the condenser.
$R_2\ R_3\ R_4 \equiv$ resistances of other arms.
$r \equiv$ resistance of cross connection.

$L \equiv$ inductance of fixed coils of electro dynamometer.
$l \equiv$ inductance of hanging coils of electro-dynamometer.
$C \equiv$ capacity of condenser.

Now, the condition that the currents in arm 1 and in the cross connection differ in phase by 90°, or that there is no deflection of the electro-dynamometer, is that

$$R_1 = \frac{R_2 R_4}{R_3} + \left(\frac{l}{C} - b^2 lL\right) \frac{R_3 + R_4}{R_4 (R_2 + R_3) + r (R_3 + R_4)}$$

The term involving $b^2 lL$ is very small, so that it may be thrown out.

R_1 calculated according to the above formula, will include both the actual ohmic resistance and the resistance due to the electric absorption. If the resistance of the arm 1 be measured and subtracted from R_1 the remainder is evidently the resistance due to the electric absorption.

A few measurements were first made, using ordinary parafine paper condensers, but the heating by the current was so great that no conclusions could be drawn from the measurements, since the absorption resistance varies greatly with temperature.

A condenser was then used which had been made in a vacuum. This showed scarcely any heating by the current, so that during several hours work in a room fairly constant in temperature, the electric absorption showed quite small variation. The condenser was one of eight micro-farads capacity. The resistance due to electric absorption of four micro-farads was 2.56 ohms, that of the other four 2.44. From these the resistance of the eight M. F. in parallel should be 1.25. The value found was 1.28.

The relation between the period of the current and the resistance of electric absorption was now studied. The period was determined accurately by means of a speed counter and chronograph; by this means the speed could be determined as closely as the constancy of speed would permit. Several series of observations were taken with the period varying from 6 or 8 to 133 per second. In all the observations taken within a few hours the temperature was assumed constant, as it would be very nearly, since there was very little heating; and any change of temperature in the room would penetrate into the condenser very slowly, as they were tightly enclosed in wooden boxes.

The following table shows the nature of the variation of the resistance due to electric absorption with the period of the current.

$N \equiv$ *number of alternations per second.*	$A \equiv$ *electric absorption resistance.*	$N \times A$
13.02	14.79	192.6
27.46	7.06	193.9
26.98	7.12	190.5
130.46	1.58	206.1
22.98	8.60	198.3
17.94	9.99	179.2
7.75	23.19	179.7
13.91	13.07	181 8
16.89	10.73	181.2
33.25	5.46	181.5

The column $N \times A$ is nearly constant throughout. This was found to be true in all the observations, with slight variations. These being easily accounted for by changes in the temperature, and in the case of the higher periods by the fact that the quantity to be found, A, is the difference between two nearly equal quantities. The above table also shows the sensitiveness of the electric absorption A to temperature changes. The first five observations were taken on one day and the others on another. The change of temperature was but a few degrees.

A series of observations were taken keeping the period nearly constant and varying R_2 from 2000 to 100 ohms and R_4 from 100 to 2000 ohms.

The following table shows the result:

R_2	R_4	N	A	$N \times A$
509.2	507.2	15.61	11.84	184.8
2071.	99.56	17.92	10.20	182.8
99.46	2044.5	18.45	10.09	186.2

The above results show that the quantity A depends in no way on the resistances in the arms of the bridge.

Another series of observations were taken, in which the period was kept constant, and the e. m. f. acting on the condenser varied.

The following table shows the results:

$V \equiv$ volts e.m.f. acting on condenser.	N	A	$N \times A$
243	17.18	11.87	203.9
76	17.95	11.72	198.7
142	19.43	10.21	198.4

This table shows the resistance due to electric absorption to be independent of the e. m. f. acting on the condenser.

It appears from the above, then, that a condenser having electric absorption may be considered as a capacity in series with a certain resistance. This resistance is a function of the temperature of the dielectric, but not of the e. m. f. acting on the condenser. It is also a function of the period of the current passing through the condenser. It varies, at least in the condenser used in this investigation, inversely as the number of alternations of the current.

Transference of Heat in Cooled Metals. By Carl Kinsley.

Several observers at different times and in different countries[1] have noticed an immediate rise of temperature at the cooler end of a bar of metal when the hot end was suddenly cooled.

Since this would be a most astonishing effect, an investigation of this matter was undertaken and carried out as follows.

Iron and steel bars of about one-half inch diameter were used, and iron-copper thermo-electric couples were soldered to the cooler end of the bar and to its side. A reflecting galvanometer was used that gave a deflection of 1 mm. per 0°.05 C. change in temperature. The end of the bar was heated by a Bunsen compound burner or in a muffle furnace with a blast lamp. The hot end of the bar was cooled either with blocks of ice or by pouring ice water upon it. The most severe conditions imposed by the above experimenters are thus fully equaled.

After errors, due to jarring the galvanometer, and to changes in the magnetic field of the galvanometer, caused by motion of the bar, had been eliminated, no effect was observed, even under the most trying conditions. The temperature of the cooler portion of the bar did not increase when the hot end was suddenly quenched. The most severe test imposed included the sudden quenching in ice water of the end of the bar, three inches of which were above the red heat. The thermo-couple then was only nine inches from the glowing end of the bar.

The galvanometer, of course, showed the usual slow change of temperature due to conduction There was, therefore, a comparatively long time after quenching before any change of temperature was indicated, and then the change was only a reduction of temperature.

A Method of Measuring the Frequency of Alternating Currents.[2] By Carl Kinsley.

When an electro-magnet is energized by an alternating current it will produce an alternating magnetic field. If a strip of iron, whose natural period is the same as or twice that of the alternating current, is rigidly held near the magnet, it will be set in vibration. Such a rod can be used to measure different frequencies by changing it in such a way as to make it vibrate synchronously with the magnetic field. The common frequency can then be computed from the physical constants of the bar. This change of the frequency of the bar is most easily accomplished by varying its moment of inertia by means of a non-magnetic rider.

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[1] M. Henry Bourget, "Astronome adjoint à l'observatoire de Toulouse, juin 14," *Nature*, June 30, 1898.
Mr. A. T. Bartlett, Cavendish Laboratory, Cambridge, 1889, *Nature*, Sept. 1, 1898.
Mr. J. S. Stone, Johns Hopkins University, Baltimore, Md., 1888, *Nature*, Oct. 20, 1898.

[2] A more detailed description of this method will be found in the *Physical Review*, April, 1899. A description of other methods that are used for this purpose is about to appear in the *Electrician* (London).

The frequency is the reciprocal of the time of one complete period (t). This time can be computed in the case of any iron or steel rod from the following equation:

$$t^2 = 1.17 \times 10^{-10} \frac{mr^3}{h\tau^3} + 2.13 \times 10^{-10} \frac{l^4}{\tau^2} \tag{1}$$

$m =$ mass, in grams, of the rider. $r =$ distance, in centimetres, of the rider from the supported end of the "clamped-free" bar. $h =$ width, $\tau =$ thickness, and $l =$ length of the bar from its support, in centimetres.

If a bar has $h = 1$ cm., $\tau = 0.056$ cm., $l = 7.7$ cm., and $m = 0.27$ g., then the equation becomes

$$t^2 = 1.80 \times 10^{-7} r^3 + 2.39 \times 10^{-4} \tag{2}$$

In practice a curve determined from this equation will be found a convenient method of quick computation. This rod can be used to measure frequencies between 64.7 and 56.1 periods per sec. The determination can be made with an error of less than ¼ of 1 per cent.

A good many kinds of iron and steel bars were tested, and the periodicity was found from autographic chronographic records. Equation (1) can be used with band iron or mild steel with an error of less than 19 per cent., but if very accurate absolute determinations are wished, it will be necessary to find the constants in the case of the rod being used.

RECENT PUBLICATIONS IN PHYSICS.

SUPPLEMENTARY TO THE BIBLIOGRAPHIA HOPKINSIENSIS.

The following list enumerates publications in the department of Physics by those who are now or who have been members of the University. It is printed for the information of their colleagues and friends and is not supposed to be complete. The latest previous list is given in Volume XVII of these *Circulars*, No. 135, p. 63, June, 1898.

Ames, J. S. New Systems of Telegraphy. (*Conservative Review, Vol.* 1, 1899.)

—— Text-book of Physics. (Review.) (*Science*, 1899.)

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—— and H. A. Rowland. The Elements of Physics. (*New York*, 1899.)

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PROCEEDINGS OF SOCIETIES.

Scientific Association.

April 27, 1899.—One hundred and forty-fifth regular meeting. The President of the Association in the chair.

Paper read:
A Description of a New Form of Multiplex Printing Telegraph, by Henry A. Rowland.

Philological Association.

March 17, 1899.—One hundred and seventy-third regular meeting. Professor Gildersleeve in the chair. Thirty-seven members were present.

Papers read:
The Legenda Aurea and its French and English Translations, by P. Butler.
The Transformations of a Legend, by W. H. Browne.

April 21.—One hundred and seventy-fourth regular meeting. Professor Gildersleeve in the chair. Thirty-two members were present.

Papers read:
Archaeological Aspects of the Mosaic Sanitary Legislation, by P. Haupt.
The Perlesvaus Romance and the "Manessier" Continuation of Crestien's Perceval, by W. A. Nitze.

May 19.—One hundred and seventy-fifth regular meeting. Professor Gildersleeve in the chair. Twenty-seven members were present.

Papers read:
The Versification of King Horn, by H. S. West.
Synecphonesis in Early Spanish Poetry, by C. C. Marden.

Historical and Political Science Association.

March 17.
History of Street Railway Legislation in Baltimore, by J. H. Hollander.
Leslie Stephen's Studies of a Biographer, by Robert Garrett.
Dixon's History of the Missouri Compromise and its Repeal, by St. G. L. Sioussat.
A Study of Gothic Architecture, by J. M. Vincent.

April 7.
The Church and Education, by H. B. Adams.
The Provincial Governor in the English Colonies, by D. E. Motley.
Muirhead's Land of Contrasts, by W. E. Martin.
Lebon's Modern France, by V. A. Renouf.
Watson's Story of France, by E. T. Dickerson.
Walker's Discussions in Education, by C. W. Sommerville.

April 21.
The Diplomacy of the Confederacy, by J. M. Callahan.
Fisher's Mediaeval Empire, by P. L. Groome.
Bishop's Corea and Her Neighbors, by J. C. Tyler.
Ladd's Higher Education, by A. T. Freeman.
Sidney Lee's Life of William Shakespeare, by O. J. Marston.
Ford's American Cruiser in the Far East, by W. S. Drewry.
Strobel's Spanish Revolution, by W. W. Brander.

May 5.
A Study of Homeless Men, by B. W. Arnold.
University Extension in Scotland, by H. B. Adams.
Bemis on Municipal Monopolies, by C. E. Persinger.
Church's Oliver Cromwell, by W. J. Boggs.
Fiske's West Indies, by G. L. P. Radcliffe.
Rogers' Men and Movements in the English Church, by W. E. Martin.
Richmond's Friendly Visiting Among the Poor, by Robert Garrett.
Belloc's Danton, by W. S. Myers.
Impressions of European University, by A. F. Lewis.

May 19.
Religious Freedom in Virginia, by W. T. Thom.
Chamberlain's John Adams, by C. E. Persinger.
King's De Soto, by W. S. Drewry.
Bennett's Downfall of the Dervishes, by W. S. Myers.
Peck's Jacksonian Epoch, by O. J. Marston.
McCall's Thaddeus Stevens, by C. C. Weaver.

NOTES FROM THE DEPARTMENT OF HISTORY AND POLITICS.

Edited by Professor Herbert B. Adams, Ph. D., LL. D.

THE LAND SYSTEM OF THE SOUTHWEST.

[Abstract of a paper read to the Southern History Conference, March 17, 1889, by J. C. Ballagh.]

The form under which land as an agent of productivity was employed in the development of the Southwest was of great political as well as economic importance to the country at large. The type, farm or plantation, finally to become predominant was to indicate both the agricultural and political affiliation of its region, and in this area more than in the old states of the North and the South or in the new states of the Northwest was there a prolonged conflict between the policies of land grants that were to result in this or that economic type with its consequent industrial effects. The factors having most influence upon the result were the modes of distribution and settlement under state or national law and the character of immigration and of adaptable products. North of the Ohio practically all of the territory known as the Northwest; i. e., some 161,500,000 acres out of a total of 169,959,680, was distributed according to the rectangular system of the United States land office, less than 5 per cent. being subject to the action of state or colonial laws and half of this, Connecticut's reserve, being so treated as to produce the same general result as the federal land laws eventually did in the creation of farms. South of the Ohio conditions were very different. More than one-third of the southern lands added to national territory were not embraced in the actual public domain. Of the nominal 151,049,640 acres but 96,049,921 were actual, Kentucky, Tennessee and the reserves of Georgia and Florida were either State public lands or individual private land. West of the Mississippi, exclusive of Alaska, an area of 198,000,000 acres, nearly one-sixth of the total, most of which was attached to the Southwest, was not a part of the nation's public land. In the western regions added to the South State and private land aggregated some 223,000,000 acres, while the actual United States public lands were 190,527,741 acres or 21,000,000 acres less. The effect of this upon the land system was great. Non-public lands were disposed of by Spanish, French, British, Mexican or State grants, and the method of their settlement, in general irregular and expansive, was in direct conflict with the system and intent of the rules of the United States land office where speculation was absent, while it conformed even in an exaggerated form to the system in vogue in the Southern States. Tennessee, completely covered by North Carolina reservations for granted claims, was settled under North Carolina laws, or Tennessee state laws based upon them, mostly in large claims, and the plantation of 640 or 1,000 acres or more was common. In like manner Kentucky was settled under Virginia or state law and practice, which encouraged indiscriminate location, surveying not before but after location, irregularity of boundaries and engrossment by companies and individuals. Land jobbing was general. Prices were low, 20 to 30 cents an acre, and immigrants received donations. Engrossment reached a climax in Texas. Between 1826 and 1836 most of her 175,887,840 acres were apportioned in but thirteen grants. Under Spanish colonization laws a league of land, 4604 acres, was allowed to every settler who was the head of a family. Single men got one-third of a league, 1476 acres, and the other two-thirds on marriage. Under the Republic "labors" of 175 acres were sold at £10, and an individual might acquire 275 "labors" or 48,125 acres. Immigrants received a league and a "labor," or 4779 acres. This resulted in non-improvement, vacancy and speculation, though inducing a large southern colonization.

Of the areas of Florida, Alabama, Mississippi, Louisiana, Arkansas and Missouri over 48 per cent. as late as 1880 remained undistributed, vacant or absorbed in other than regular agricultural and bounty grants; 88,441,788 acres were granted to the states for internal improvements and various reservations; 9,846,612 were absorbed or claimed under British, Spanish or French grants, so that 103,478,588 acres, barely half the total area, remained to be distributed by the national land office and some 13,000,000 of this were homesteads claimed after 1863. The land system of these states was then more influenced by the old grants than the new. The old rural grants varied from several hundred to thousands of acres, the league square of 7056 *arpents* not being unusual. Such plantations were to be found along the Mississippi river from Missouri to Louisiana, along the gulf and up the rivers of Alabama and Mississippi and scattered through east and west Florida.

Expansive crops tended to increase plantation acreage. Here sugar and cotton had the same effect as tobacco, indigo and rice in the old states of the South. Louisiana sugar plantations between 1827 and 1830 varied from 800 to 2000 and 3000 acres planted, the average being about 1200. Later it was found that a plantation of less than 1500 acres was operated at a comparative loss in net profit. Arkansas and Louisiana cotton plantations that had 400 acres under cultivation in 1839 in seven years increased by over a third with a practically constant labor force. The demand for cotton induced the rapid settlement of the Southwest at the same time that it encouraged a speculation which led to engrossment even of public lands, particularly in the South Carolina and Georgia cessions where some 59,000,000 acres were available. Public land could be bought at $1.25 an acre and sold at $6.44, which though one dollar more than the price in the old states was supported by the inflated currency and high price of cotton. In 1850, regardless of the depression following 1841, Arkansas and Mississippi cotton plantations were seldom less than 400 acres and in some cases were 10,000. An average for the cotton states was 675 acres under cultivation but those of Mississippi and Alabama were less. In a few years they increased to an average of 600 acres for the middle class plantation, while the best ones in Mississippi were from 13,000 to 14,000 acres. In 1860, in the cotton states from North Carolina to Texas, there were 4000 plantations having over 1000 acres and many times this number having from 500–1000 acres. Three types of plantation were developed according to location: (1) The river and gulf plantation on the Mississippi and the Gulf of Mexico and their tributaries. These were large and employed slaves by hundreds; (2) The inland plantations usually of some 600 acres employing about 50 slaves; (3) The Piedmont plantations, of 400 acres or less, cultivated by 30, 20, 10 or even fewer slaves. Only in the highland regions was the effect of the public land system visible. Here were the grain rather than cotton farms of the poor non-slaveholder or small slaveholder. These were numerous enough in 1850 to reduce the average farm acreage to 287 in Alabama, 309 in Mississippi, 372 in Louisiana and 146 in Arkansas. But by 1860 expansive products had raised these averages to 346,370,536,245 acres respectively, while the development in the old states owing to the decadence of agriculture, and, in the South, to the manumission or exportation of slaves, was the reverse and a decrease from an average of 366 to 329 acres and in the North from 116 to 105 acres.

The Southern land system was peculiarly fitted to an era of agricultural exploitation, but when that was passed it tended to develop harmful effects from exclusive agriculture, isolation, non-improvement and absenteeism that would outbalance its beneficent ones.

SLAVE INSURRECTIONS IN VIRGINIA.

[Abstract of a paper read by W. S. Drewry to the Southern History Conference, November 11, 1898.]

The study of slave insurrections necessitates a review of the institution of slavery. The history of slavery as developed in Virginia naturally follows the three characteristic periods of United States history. Previous to 1783, slavery was not, economically considered, a very important factor as far as Virginia was concerned. She was striving to rid herself of it and never ceased to believe that she would be successful. Not until 1661 did an act first legally recognize this species of property. The purpose was to prevent the evil schemes and machinations of Indians and unprincipled white servants. For more than forty years the negro stood on an equal footing with the dependent whites, and indented servitude included negro servants who were distinguished from white only by their color. The colonial records need only be consulted to substantiate this fact. While the negro slave had the disadvantages incident to his color, the indented white servant was at a disadvantage in many respects greater as to maintenance and protection. The negro was regarded as a mere tool in the hands of the more intelligent servant, and for this reason he excited a sympathy which bettered his condition and rendered it in every respect superior to the European peasant. The negro was a protégé of the colony, to be educated for the purpose of civilizing his fellow beings of the dark continent. This was the period when England declared that the slave trade was most beneficial and not to be restrained. Her policy was to rivet slavery upon the North American continent in order to destroy manufacture and encourage agriculture. Masters were employed to restrain the slaves, and slaves were in turn aroused to rebellion to suppress the opposition of the whites to the schemes of the mother country. Notwithstanding this policy, Virginia recognized the free negro as a citizen with most of the rights of his white brother. At the first meeting of the legislature of the Commonwealth in 1777 an act was passed prohibiting the enlistment of only those negroes and mulattoes who had no certificate of freedom. Many of these enlisted in the service of the colony and their services were recognized by the State legislature. The insurrectionary attempts of this period were local and few in number.

For fifty years no signs of rebellion appeared. After 1668, there are four other attempts, if the murder of a master and his family can be termed an insurrectionary attempt. The first forty-seven years of the Commonwealth of Virginia are characterized by the same vehement opposition to slavery. In 1783, there was passed "An Act concerning the emancipation of certain slaves who had served as soldiers in this State." This was a step in advance of the Act of 1778, which prohibited the further importation of slaves into the Commonwealth. England had changed her policy and a strong abolition sentiment arose in the absence of an economic interest in the institution of slavery. This moral sentiment was carried so far that she deemed herself justifiable in violating international law, which was rendered possible only through the natural and reasonable sentimental sympathy aroused in those sections of the United States, furthest removed from the dangers of servile discontent. It was not, as many historians would lead us to believe, that Virginia's policy changed. She still strove to rid herself of the negro, but was unfortunate in being forced into a position which at first sight would appear to her discredit. The idleness and dissipation acquired in the camps of the French and English exhibited themselves in the negroes of this period. English spies were arrested in attempts at arousing the slaves to rebellion, and when English efforts were slackened, French influence took its place. The refugees from the St. Domingo Massacre of 1793 arrived in the United States. Many of their slaves had followed them voluntarily, but the majority were forced aboard the vessels and brought to Virginia. Their immediate influence was seen in the various attempts at revolt in all Eastern Virginia and Carolina. From 1792 to 1812 occurred three-fourths of the slave revolts in the history of the State.

The Gabriel Insurrection, which took place in Richmond in August, 1800, is the central fact of this period, and was the first servile attempt of any importance. More than one thousand slaves were implicated. Between 1814 and 1830, there was comparative quiet, and only one alarm was occasioned by the slaves. The convention for revising the constitution of the State met in 1829. The slaves were informed by some suspicious persons that it was called for the purpose of emancipating them Consequently, they determined to murder all the whites in case of a failure.

The French influence had not been extinguished in 1831, the beginning of the third period of our study. It was seen in the Southampton Rebellion of August, 1831, which is given by most histories as the second and last rebellion of the slaves of Virginia. This rebellion and the alarm of 1829 together with the presence of great numbers of abolition missionaries tended to arouse a spirit of opposition to emancipation. In 1833, the slaves of the British West Indies were freed. The South American States had previous to this followed the same course. Thus there were three great bodies of free negroes ever threatening the slave States. The danger from this direction together with that from the Creek, Cherokee and Seminole Indians was the cause of much slavery legislation, which because of its frequency has been characterized as most stringent and cruel, but which to the careful student resolves itself into a series of acts for the prevention of slave rebellion and the spread of insurrectionary doctrines from Indians, unscrupulous whites, French and British. The last insurrectionary attempt was the John Brown Raid.

In all, there were about fifteen slave revolts in Virginia, all of which were local and included those cases in which only a few slaves were implicated. The characteristic feature of each is that at the bottom of it was white or Indian influence, which played upon the credulity and superstition of the negro and used as a tool some fanatic, who was only too ready to undertake the task of freeing his race. Each plot was discovered by means of some faithful slave who of his own will reported it to his master and led his fellow servants to stand loyally by the whites. A total of one hundred people were slaughtered by insurgent slaves in Virginia and the history of slave insurrection but serves to emphasize the generally humane and kind treatment of the negro and portrays in the ante-bellum slave a true nobleness and heroic manhood, worthy of the Christian white. From 1829 to 1865 not more than thirty slaves were guilty of actual rebellion and conspiracy. During the War when rare opportunities for murder, rapine, and insurrection were offered, a loyalty was shown by the slaves unsurpassed for the devotion of dependents to their superiors.

INTERNAL IMPROVEMENTS IN NORTH CAROLINA.

[Abstract of a paper read by Chas. C. Weaver to the Southern History Conference, February 17, 1899.]

Agitation over the question of internal improvements began in a marked degree in North Carolina just after the close of our second war with Great Britain. Numerous schemes had been presented before this time and considerable work had been done, but the period of greatest activity was from this time on. Agitation was soon intense. Conventions were called, resolutions adopted and addresses presented by leading citizens, all showing the necessity of opening up routes of trade both into and through the State. The improvement of transportation facilities as the avenues of commerce received chief attention.

In the movement for internal improvements was involved much more than at first appears. It was political as well as economic. At this time the most intense jealousy and rivalry existed between the different sections of the State. Under the constitution of the State certain counties in the east were entitled to more than one representative in the legislature. As the west was being rapidly settled, the matter of inequality of representation in comparison with the population of the two sections became a serious one. The west stood for unrestricted suffrage and equal representation, while the east was content to leave undisturbed the system which insured to them political supremacy. This jealousy entered into all considerations for internal improvements. Each section was determined that the other should not receive more than its share of attention on the part of the State. In trying to steer between the factions and to please both the State dissipated its resources and brought to naught much work that would have had good results if it had been rightly applied in any one locality—but scattered as it was, the state money could do but little good.

It will be unnecessary to follow all the various schemes that were planned at different times. A general outline of the whole system of improvements may be gotten from the following brief summary.

Improvements related, first, to inlets and sounds on the coast. Of the former the two that attracted considerable attention were the Ocracocke and the Cape Fear. The central position of the latter made it peculiarly important, while the commerce of the Tar, Neuse and Roanoke were held to be dependent on the Ocracocke. Difficulties in the way of these directed attention to the inlet at the end of Albemarle Sound.

The very first attempt that was made at improvements was directed toward rendering the rivers navigable. In addition to those mentioned, the Cape Fear, the Yadkin, the Catawba and the Broad all received the attention of the Legislature. The plans included not only making these navigable, but also connecting them by canals. Then, too, roads must be constructed in places where there were no rivers. Thus it is seen that the middle of the State was to be satisfied by the improvements of the rivers, the west by the building of roads and the east must also be helped by the draining of the swamps and marshes of the eastern and southern parts of the State. It was claimed to be a matter of moment for the nation that the coast should be made accessible and demands were made upon the United States government for the State's share in federal surveys and improvements.

After the building of railroads began, the great scheme was to secure inland communication by water from New York to Beaufort and from thence by the rivers to the middle of the State, and thence west by rail reaching the Tennessee River and finally the Mississippi by a shorter route than that by the Erie Canal. Thus it was thought that the whole western trade would flow through the State.

North Carolina's experience in railroad making has been varied and painful. It began with the plan for one central line through the State which should be run without respect to centres of population but should follow an air line through the centre of the State. This was the pet scheme of President Caldwell of the University.

As a result of the war and of the numerous internal improvements that were undertaken up to 1871, North Carolina had contracted a debt of nearly $35,000,000. Of this amount over $12,000,000 was the result of bonds issued to railroads by the legislature of 1868–69. Nearly all these had been sold at ruinous rates, many bringing only 10 to 30 cents on the dollar. In 1876 accrued interest raised the debt to nearly $42,000,000. The State still possesses an interest in a few of the roads of the state, but in recent years troubles that have arisen about them have almost destroyed their real value as a public investment.

RECENT PUBLICATIONS IN HISTORY, POLITICS, AND ECONOMICS.

The following list enumerates publications, since the list published in the *University Circulars* for February, 1897, in the Department of History and Politics, by those who are now or who have been members of the University. It is printed for the information of their friends and colleagues and is not supposed to be complete.

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The Johns Hopkins Press has just published as extra volume XX of the Studies in Historical and Political Science, **The Financial History of Baltimore,** by J. H. Hollander, Ph. D., Associate in Economics in the Johns Hopkins University. 400 pages, octavo. (Price, $2.00 net.)

It is probably the first exhaustive study of the financial history of an American city. The author traces in detail the development of municipal expenditure, revenue, indebtedness and financial administration through the several periods of pre-corporate and corporate history. It has been found desirable to make use almost exclusively of original sources, and to emphasize the influence of administrative change upon fiscal growth. The narrative proper is supplemented by critical comment and constructive suggestion. The volume appears with peculiar timeliness, as Baltimore is about to celebrate a centenary of corporate existence by the inauguration of a new reform charter. While primarily of local interest, the book appeals to all students of local finance who will recognize many phases of the experience of Baltimore as typical of the American city. The work is fully equipped with the requisite statistical appendices.

PUBLIC MEETINGS AND SOCIAL ASSEMBLIES

Recently held in the University Buildings:

Concert by the Johns Hopkins Musical Association, in McCoy Hall, March 18.

Reception by the Young Men's Christian Association, in honor of Rev. Dr. Clarke, Levering Lecturer, in Levering Hall, March 20.

A meeting of the Municipal Art League of Baltimore, in the Donovan Room, March 27.

A public meeting in furtherance of the movement to bring about universal peace, with an address by Rev. Dr. Edward Everett Hale, in McCoy Hall, April 6.

Illustrated lectures, in McCoy Hall, before the Baltimore Society of the Archæological Institute of America, by Professor T. D. Seymour, of Yale University, on "A Midsummer Trip to the Lands of Hellas," April 7; and by Professor Charles Waldstein, of the University of Cambridge, on "The Excavations of the Argive Heraeum," April 22.

The annual meeting of the Phi Beta Kappa Society in the Donovan Room, April 13; also an address before the Society by Professor George Adam Smith, of Glasgow, in McCoy Hall, followed by the annual banquet, April 29.

Celebration of the one hundredth anniversary of the founding of the Medical and Chirurgical Faculty of Maryland, in McCoy Hall, April 25, 26, 27, 28. During the meeting a most noteworthy series of exhibits was on view in the corridors and rooms of McCoy Hall. These included: portraits, busts, and relics of founders and of distinguished deceased physicians; books and portraits to illustrate epochs in the history of medicine; books to illustrate the condition of medicine in the year 1799; and works illustrating the development of art in medicine.

Regular monthly meeting of the Maryland Folk Lore Society, in the Donovan Room, March 24, and a public meeting in McCoy Hall, April 28.

A meeting to organize a "George Junior Republic" in Maryland, in the chapel of Levering Hall, May 4.

The opening session of the annual meeting of the Itinerants' Club of the Baltimore Conference of the M. E. Church, in Levering Hall, May 16. Addresses by Dr. Griffin and Dr. Adams.

A public recital of the musical compositions of Mr. Edwin L. Turnbull (A. B., '93), in McCoy Hall, May 22.

George Huntington Williams Memorial Lectures, 1900.

Professor W. C. Brögger, of the University of Christiania, the distinguished Norwegian geologist, has accepted an invitation to deliver the second course of the George Huntington Williams memorial lectures at the Johns Hopkins University, in April, 1900.

Professor Brögger is the most prominent Scandinavian geologist, and has published a series of memoirs upon the geology of Southern Norway that have given him rank among the leading investigators of his time. Professor Brögger comes as the successor in the Williams course to Sir Archibald Geikie, the Director-General of the Geological Surveys of Great Britain and Ireland, who opened the lectureship two years ago with a course upon The Founders of Geology. Professor Brögger will lecture upon Modern Deductions regarding the Origin of Igneous Rocks, a subject that has been commanding the attention of geologists in recent years.

In the Studies in Historical and Political Science the following works are in preparation and will soon appear:

Cuba and International Relations. By Dr. J. M. Callahan.
Studies in State Taxation, with Particular Reference to the Southern States. By Dr. J. H. Hollander.
The Labadist Colony in Maryland. By Dr. B. B. James.
History of Slavery in North Carolina. By Dr. J. S. Bassett.
History of Slavery in Virginia. By Dr. J. C. Ballagh.
The Admission of Iowa into the Union. By Dr. J. A. James.
The History of Suffrage in Virginia. By Dr. J. A. C. Chandler.

PROFESSOR SIMON NEWCOMB.

[Reprinted from *Nature*, London, May 4, 1899. The following sketch is by Professor MAURICE LOEWY of Paris, Director of the Paris Observatory, President of the Bureau des Longitudes, Paris, and Member of the Academy of Sciences, Paris.]

Newcomb must be considered, without contradiction, as one of the most celebrated astronomers of our time, both on account of the immensity of his work and the unity of view which marks the choice of the subjects treated by him.

All is linked together in our solar system: the study of the motion of each one of the celestial bodies forming part of it is based upon the knowledge of a great number of numerical data, and there exists no fundamental element whose influence is not repercussed on the entire theory of these bodies. To endeavor to build up the theory of our whole planetary world on an absolutely homogeneous basis of constants was an almost superhuman task.

The evaluation of each one of these data demands, indeed, that one should attentively go over most of the previous researches, and continue them by more thorough methods. All Newcomb's work, followed up with rare perseverance, has constantly tended to this ideal end: first to arrive at a more exact knowledge of the magnitudes serving as points of reference, and then to establish the theory, not only of all the planets, but also of their satellites on a system of constants as precise as modern observations permit. Wishing to realize in a complete manner this vast programme, Newcomb has recognized that the published observations do not always furnish the necessary information for obtaining with exactness all the looked-for elements Abandoning, therefore, the domain of pure speculation, he has given himself up to researches which proclaim him possessed of a talent of observation of the highest order. By personal studies he has succeeded in filling many of the gaps which seriously impeded the progress of theory. Thus, in order to determine the masses of Neptune and Uranus and the elements of their satellites, he made a series of observations of great value, on which are partially founded the ephemerides inserted in all nautical almanacs.

I shall simply mention here in a few words some of the preparatory work preceding the construction of the magnificent edifice of which I have indicated the plan, on the happy completion of which the scientific world is to be congratulated. Throughout its execution one recognizes the sign of a master-mind whose conclusions assume a definite character and remain acquired to science.

The solar parallax is one of the most essential data which intervene in all researches concerning the planetary system. Newcomb undertook to fix its value by the discussion of all the transits of Venus observed previously to 1882. In a very detailed memoir, he calls astronomers' attention to the danger to which they are exposed by giving an exaggerated confidence to certain modern methods. The systematic exclusion of the ancient observations cannot sufficiently be justified by discordances which exist between their results and those obtained more recently. By a minute and impartial discussion of all existing documents, Newcomb arrived at a value almost identical with the one adopted in 1896 by the International Conference of Paris.

Again, in order to obtain by an altogether independent means the value of this same constant, Newcomb undertook a determination of the velocity of light, based on the ingenious method suggested by Léon Foucault. These researches of a physical nature opened the way to an important advance in our knowledge of the heavens. In fact, we had all reason to hope that the value obtained for the velocity of light, combined with the constant of aberration, would allow us to determine the solar parallax more accurately than by the usual astronomical methods. Newcomb holds that multiplicity of methods is an essential condition of success; this motive led him to choose Foucault's method, which he applied with rare sagacity. The agreement between the different results obtained in this way by Cornu, Michelson and Newcomb is an admirable one, and testifies to the knowledge and skill of the experimenters. With the help of the values found for the velocity of light, it would have been possible to deduce the parallax, if recent observations had not revealed the uncertainty which still hovers over the real value of the aberration constants.

I cannot close the list of these preparatory studies without referring to a subject which interests the highest problems of astronomy of precision.

The observations of the planets and of the moon depend on the coordinates of the fundamental stars, of which unfortunately we possess as yet no catalogue absolutely free from systematic errors. One of Newcomb's constant preoccupations was to try to constitute a uniform system of points of reference, at least in right ascension, this coordinate having weighty importance in the case of observations of moving bodies. The catalogues drawn up by him, and by Auwers, for the fundamental and bright stars of the ecliptic, have shared in equal measure up to a very recent date the favor of astronomers. But the use, in the same scientific research, of elements derived from different sources, presents inconveniences acknowledged for a long time. A reform in this direction had become very desirable. This circumstance has again afforded Newcomb the opportunity of manifesting the inexhaustible resources of his activity and talent. An international conference, held in Paris in 1896, under the auspices of the Bureau des Longitudes, had as its object to elaborate a common system of constants and fundamental stars to be employed in the astronomical ephemerides. Newcomb took one of the most important parts in the discussions and resolutions of this conference. At its suggestion he has undertaken, not only the research of the definite values to adopt for the lunar-solar precession and the planetary precession, but also the construction of a new catalogue of fundamental stars in accordance with the system of elements chosen by the Paris meeting of astronomers. Newcomb has consecrated these two later years to the accomplishing of this arduous task. The catalogue of fundamental stars, which he has just finished, will come into use in the beginning of 1901, and will realize in the work of astronomers that unity and simplification so long desired.

I now come to the labors which have absorbed the greatest part of Newcomb's scientific activity: they refer to the domain of celestial mechanics.

At the time when the great work of Le Verrier had only reached the tables of Jupiter, Newcomb published an excellent theory of the two planets furthest from us, Uranus and Neptune. These tables, from the moment of their appearance, have been used by astronomers of every country.

Among the greatest triumphs of Newcomb's career must be counted his many and fruitful researches on the motion of the moon. The theory of the moon bristles with difficulties. No one has yet succeeded in establishing a complete harmony between theory and observation. In his lunar tables, Hansen, in order to obtain this accordance for a limited interval of time, was obliged to attribute to an inequality arising from the action of Venus an empirical coefficient of an excessive amount, and to adopt besides an acceleration of the secular movement twice as great as that which results from the law of universal gravitation according to the calculations of two illustrious geometricians, Adams and Delaunay. Should we, as a great number of *savants* think, attribute to Hansen's number, so far from the theoretical value, an indisputable reality, and try to discover the physical causes of the anomaly; or should we see the origin of the disagreement in an erroneous interpretation of historical documents? Newcomb did not recoil before the difficulties which the solution of this problem entailed. He discussed all the occultations observed since the invention of the telescope up to a recent time; he himself examined forgotten observations, buried for one hundred and fifty years in the registers of the Paris Observatory. These neglected documents have thrown a vivid light on the question. In thus utilizing an abundant harvest of new information, and correcting Hansen's theory by the exclusion of every empirical coefficient, Newcomb arrived at results of fundamental importance. He proved, agreeing in this with Tisserand's researches, that the eclipses of the Almagest and those of the Arabs, as well as the ancient occultations, agree very well with the theoretical value of the secular acceleration; and further, as a corollary, that the most ancient solar eclipses, the representation of which would seem to demand an increase of the secular acceleration, can without scruple be left out of consideration, either because the reality of the phenomenon remains doubtful, or because there exists too great an uncertainty in the hour and place of observation.

One might without inconvenience, therefore, adopt the theoretical acceleration of 6″, correcting the mean motion and the longitude of the epoch. But whatever value is chosen, and this was not anticipated, one must, after having suppressed Hansen's erroneous inequality, resign oneself to introduce another notable empiric term of a period of about two hundred and seventy years, and of an unexplained origin; one simply notes that this amplitude is nearly that of an inequality due to Venus, the existence of which is not doubtful.

Besides this empiric inequality, Newcomb has discovered another, less pronounced, with a coefficient superior to 1″, with an amplitude of about twenty-seven days, and appearing to be associated with a long period perturbation of the excentricity and perigee. These delicate deductions have since been confirmed by the theoretical researches of Messrs. Neison and Hill, which show that the terms in question are due to the action of Jupiter. By all these investigations, Newcomb has elucidated, in a masterly way, the actual state of the theory of the motion of our satellite.

The two theories of the moon which must be considered the best are those of the two celebrated geometricians, Delaunay and Hansen; they are founded on totally different methods. By the help of a long, minute and tedious transformation, because it is a question of formulæ occupying several quarto volumes, Newcomb has rendered their expressions immediately comparable, bringing them moreover to a system of precise and uniform constants.

Further, by this comparison, he has shown that, in spite of the difference of method, the two theories lead to identical results for solar perturbations, which form the essential part of them and are indeed the only ones which were calculated by Delaunay.

I must now pass very briefly to some of Newcomb's other memoirs. One of his most original researches is relative to Hyperion, Saturn's seventh satellite, discovered almost simultaneously by Bond and Lassell. The movement observed was in disaccord with the prediction of theory. In fact the major axis of Hyperion's orbit, instead of moving, directly, round Saturn in a century, accomplished a revolution in the opposite direction in the short period of eighteen years.

Newcomb has proved that this rapid retrograde revolution is caused by the perturbing action of the next satellite Titan.

In the various volumes of "The Astronomical Papers for the use of the American Nautical Almanac," Newcomb has published a great number of memoirs. One can follow step by step the immense progress achieved in the execution of the vast project which he had taken upon himself to accomplish.

It is difficult to convey an idea of the considerable efforts, the sagacity which must be displayed, the numerous investigations which must be accomplished, in order to make known to a sufficient degree of approximation the motion during a century of a body of our planetary system. Only those scientific men who have given themselves up to analogous studies can appreciate the enormous expenditure of physical and intellectual energy which must have been necessary to Newcomb in order to bring to a happy end the researches on the four planets nearest the sun. Newcomb has based his work on more than 60,000 observations, which he has compared with Le Verrier's tables; the perturbations have been calculated with great precision. While Newcomb has thus founded theories of these planets on a more precise basis, his celebrated collaborator, Mr. Hill, has obtained the same results for the two planets Jupiter and Saturn.

Henceforth, science will profit by the fruits of this immense labor, consisting of the tables of the planets Mercury, Venus, Mars and the Earth. In a special volume there are to be found various researches on the fundamental constants of astronomy.

We have only been able to give a short sketch of Newcomb's achievements; he is gifted with a prodigious power of work, which is testified by the extraordinarily long list of his researches.

The reception which has been accorded to them by all competent men points to their author as one of the most illustrious representatives of celestial mechanics.

This activity has embraced the most diverse branches of astronomy. Not only has he given a great scope to the intellectual movement of his country, but he has also contributed in a very successful manner to elevate the level of the civilization of our age, enriching the domain of science with beautiful and durable conquests.

Loewy.

PRESENTATION OF A PORTRAIT OF PROFESSOR REMSEN.

In December 1897, a circular letter was sent to Professor Remsen's former students, requesting their aid to secure his portrait for the University. The response was so prompt and hearty that the committee was enabled, before the summer vacation, to present the project to Professor Remsen and to request him to sit for the portrait which was painted, during the summer, by Mr. Robert Gordon Hardie at Brattleboro, Vermont, where Professor Remsen very kindly consented to spend part of the vacation and thus secure a portrait painted under the most favorable circumstances. The portrait represents him in a sitting position with one arm resting on the arm of a chair. It is an excellent likeness and a fine work of art and will be as great an accession to the University collection as that of Professor Newcomb, which was painted by the same artist. Besides the former and present students, some of Professor Remsen's colleagues and personal friends assisted in securing the portrait. It was formally presented at the public Commemoration exercises on February 22, by Dr. J. Elliott Gilpin, who had acted as secretary of the committee, and was accepted, on behalf of the University, by Mr. C. Morton Stewart, President of the Board of Trustees. In presenting the portrait to the University Dr. Gilpin said: "I have the pleasure of presenting to the University, on behalf of the former and present students and some of the associates and friends of Professor Remsen, his portrait which was painted last summer at Brattleboro, Vermont, by Mr. Robert Gordon Hardie. In doing so I cannot refrain from expressing, in their behalf, their appreciation of the great benefits they have derived from their intercourse with Professor Remsen as an instructor and a friend. They have been inspired and encouraged by the example of his enthusiasm and have gone out to their life work with high aims and ideals. These men are now exerting their influence for the advancement of their profession and the welfare of the nation, and are distributed over more than 30 states from Maine to California and from Minnesota to Louisiana. As for his work in behalf of the University and this city, no words of mine are necessary to you who know so well the part he has played in the growth of this institution and in all matters concerning the welfare of the city. It is then as a slight token of our appreciation of his services in our behalf that we present this portrait to be hung on these walls with the portraits of those whose labors and noble deeds in behalf of this University will ever be recalled by these portraits. In this paper will be found the names of those for whom I now present this portrait to the University."

This list was as follows:

Students.

Alleman, G.
Arbuckle, H. B.
Ballard, H. H.
Base, D.
Berkeley, W. N.
Blackshear, C. C.
Brackett, R. N.
Brewer, C. E.
Brigham, C. P.
Bromwell, W.
Bucher, J. E.
Cameron, F. K.
Caspari, C. E.
Chamberlain, J. S.
Dashiell, P. J.
Day, D. T.
Day, W. C.
Dohme, A. R. L.
Emerson, W. H.
Fay, H.
Franklin, E. C.
Fraps, G. S.
Gilpin, J. E.
Gray, G. W.
Griffin, J. J.
Hall, L. B.
Hart, E.
Hartman, R. N.
Henderson, N. E.
Herty, C. H.
Higbee, H. H.
Hillyer, H. N.
Hite, S. H.
Hollis, F. S.
Holmes, W. B.
Holmes, J. H.
Hopkins, A. J.
Hunter, J. R.
Jones, H. C.
Jones, W.
Jones, W. A.
Kastle, J. H.
Keiser, E. H.
Kilgore, B. W.
King, S. H.
Kohler, E. P.
Lengfeld, F.
Mackay, E.
Magruder, E. W.
McKee, S. R.
Metcalf, W. V.
Moale, P. R.
Muckenfuss, A. M.
Nakaseko, R.
Newell, L. C.
Norris, J. F.
Norris, R. S.
Noyes, W. A.
Orndorff, W. R.
Palmer, C.
Palmer, C. S.
Parks, R. N.
Ragland, C. D.
Randall, W. W.
Richardson, G. W.
Russell, G. W.
Saunders, A. P.
Shober, W. B.
Slack, H. R.
Slagle, R. L.
Stoddard, W. B.
Stokes, H. N.
Ullmann, H. M.
Waters, C. E.
Weida, G. F.
White, J.
Wilson, F. D.
Wolff, F. A.
Young, A. V. E.

Colleagues.

President Gilman, and Professors Abel, Ames, Griffin, Halsted, Hurd, Morse, Renouf, Rowland, Welch, Barker, Reid, and J. W. Williams.

Personal Friends.

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